ARMY RESEARCH LABORATORY

Validation of Improved Research Integration Tool (IMPRINT) Driving Model for Workload Analysis

by Josephine Q. Wojciechowski

ARL-TR-3145 **April 2004**

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Army Research Laboratory

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14. ABSTRACT

The Human Research and Engineering Directorate of the U.S. Army Research Laboratory developed a model of the tasks and workload associated with driving a ground vehicle. The human performance modeling tool, Improved Performance Research Integration Tool (IMPRINT), was used to simulate the driving tasks. Perception, cognition, and motor control were represented in the IMPRINT driving model. Human processing, attention, and response were simulated as concurrent discrete events. Subsequently, the driving model was incorporated into other IMPRINT models used to investigate crew size and function allocation in Future Combat Systems (FCS) conceptual ground vehicles. Driving is a primary crew function in FCS ground vehicles. The results of this study indicated that a dedicated driver was recommended in combat vehicles. In all configurations tested, the driver was consistently the crew member with the highest workload.

As expected, results of simulation runs were consistent with research on driving and distraction. Structural and output validation of the model was completed through literature review. Driving by itself is a high mental workload function. The human processing capacity is fully engaged in tasks when one is driving, with the primary load being in perception and cognition. Literature shows that performance will start to degrade if additional tasks are attempted during driving, especially if the tasks are highly perceptual or cognitive.

This model provides a reasonably simple way to represent the driving function and can be used for investigating any system where driving is important. For FCS, this will include direct driving and teleoperations. Several additional validation studies are planned.

15. SUBJECT TERMS

driving; human performance; modeling; task network; workload

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1. Introduction

Driving is a routine task performed every day. As people gain experience in this task, many of the required actions become "automatic." This means that an experienced driver may not require the same level of mental effort as a novice (Schlegel, 1993). In today's society and technological revolution, driving is sometimes secondary to activities such as talking on the telephone, reading electronic mail, eating, and determining the vehicle location on in-vehicle navigation systems.

Likewise, in the U.S. Army, the transformation of the Army is calling for Soldiers to do more tasks with better technology. In many instances, combat vehicle crew size is being reduced. The idea is that with increased technology, the soldier will have more time to do more tasks. Recent investigations into combat crew function allocation have shown that driving is a large contributor to mental workload (Mitchell, Samms, Henthorn, and Wojciechowski, 2003). Allocating additional functions to the driver increases the potential for performance errors. It may not be safe to perform any secondary task while driving, even for experienced drivers.

In 2001, the U.S. Army Research Laboratory (ARL) developed a model to investigate off-road driving from one location to another. This model represented tasks that were necessary to drive. The model was exercised in an experiment with three driving modes (direct driving, teleoperation, and semi-autonomous), two levels of obstacles (high and low frequency), and two levels of vehicular reliability (high and low) (Wojciechowski, Kogler, and Lockett, unpublished). Subsequently, in 2002, that off-road driving model was used in another study that investigated the allocation of function in a combat vehicle for the Future Combat System (FCS). The results of the second study indicated that driving was the highest workload contributor (Mitchell et al., 2003). Any additional mental workload may cause errors. Because the driving function was so critical to the FCS crew function allocation study, this effort to establish the validity of the driving model was undertaken. The purpose is to validate the driving model as a component for use in this and other vehicle system models.

2. Background

Modeling and simulation are often used to predict human performance in situations when it is not feasible to run an actual field study or laboratory investigation. ARL developed a simulation tool called Improved Performance Research Integration Tool (IMPRINT), which is a discrete event simulation that measures system performance as a function of human performance (Allender, Kelley, Archer, and Adkins, 1997). IMPRINT includes measures of task and mental workload.

In 2001, IMPRINT was used to predict human performance in different driving modes (Wojciechowski et al., unpublished). The investigation compared mission completion time, mission success rate, and operator mental workload of several different driving conditions: driving control mode, obstacle rate, and vehicle reliability rate. The control modes of interest are driving the vehicle yourself while you are in it (self driving), controlling every aspect of a vehicle from afar (teleoperation), and supervising a semi-autonomous vehicle from afar (semi-autonomous). The objective of the investigation was to develop a model of varying levels of operator control of a ground vehicle movement task to assess the effect on human information processing and total system performance.

In 2002, this driving model was used with other combat functions in an investigation of function allocation for the combat variant of FCS (Mitchell et al., 2003). This study combined driving with other combat functions, gunning and commanding, to determine the number of crew members required to successfully complete a combat mission. The three major functions of commanding, gunning, and driving were distributed in different combinations of two-person crew and one allocation of three-person crew. The four conditions tested are given in table 1.

Table 1. Test conditions for FCS function allocation study.

Condition	Function allocation
1	Commander-Driver and Gunner
2	Gunner-Driver and Commander
3	Commander-Gunner and Driver
4	Commander, Gunner, and Driver

The results of the study indicated that driving was a high mental workload task. In each of the conditions tested, the driver was the crew member with the highest workload. Even in the conditions where no additional tasks were assigned, the driver had the highest workload. Additionally, the workload levels that were reached by the driver indicated that the driver was at or near the mental workload threshold.

A validation effort was initiated when the results of this investigation revealed the importance of driving. Validation can be accomplished in different ways. Army regulation 5-11 (AR 5-11) states, “Validation is the process of determining the extent to which the M&S (model and simulation) adequately represents the real world from the perspective of its intended use” (1997). Department of the Army Pamphlet 5-11 (DA Pam 5-11) states there are two components to validation (1999). The first component is structural validation and it focuses on review of the assumptions and architecture of the model. The second component of validation is output validation. This type of validation compares the output of the M&S to the perceived real world. The present report addresses both structural and output validation of the driving model.

To complete the validation effort, a complete description of the model and modeling assumptions is provided, followed by validation of the model components through comparison to other driving models. The observation that “driving is a high workload task” is consistent with data

from the literature. This demonstrates output validity. The validation is followed by a short discussion and description of future work.

3. Model Description

The model representing the three driving methods was developed in IMPRINT version 6 (Wojciechowski et al., unpublished). IMPRINT has a task and workload analysis capability to assess the impact of task load demands on human and system performance (Allender et al., 1997). This latest version of IMPRINT allows the representation of human tasks as goals. Because the driving task is a highly cognitive task, there is a need to represent human behavioral components. An important human information processing feature of IMPRINT is the capability to model mental workload demands. The VACP (visual auditory cognitive psychomotor) workload theory implemented in IMPRINT is discussed in detail in a U.S. Army Research Institute technical report (McCracken and Aldrich, 1984). Workload theory is based on the idea that every task a human performs requires some attentional resource demands. Some tasks are highly automated and require very low resources while others require full concentrated attention. Usually a task is composed of several different types of demands, such as visual or cognitive. IMPRINT is structured to help assign values representing the amount of effort that must be expended in each resource in order to perform each task. IMPRINT uses a list of scale values and descriptors for each resource channel. These scales are taken directly from Bierbaum, Szabo, and Aldrich (1989). Each scale ranges from 0.0 to 7.0 and has benchmarked textual descriptors corresponding to increasing demanding tasks in that channel. The descriptors correspond to increasing levels of human information processing activity within a given channel. Functions, tasks, and goals for the model were developed by hierarchical task analysis methods (Kirwan and Ainsworth, 1992) and were then augmented by cognitive task analysis methods to capture the non-physical aspects of driving and controlling vehicles (Cooke, 1994). Discussions with ARL subject matter experts about teleoperation and semi-autonomous driving were critical to this process. Task duration times not covered by modeling assumptions were developed on the basis of data and algorithms in literature (Wierwille, 1993; Archer and Adkins, 1999).

In IMPRINT's goal orientation option, the primary goal consists of the basic mission that must be accomplished (Archer and Allender, 2001). Other goals may conflict or interact with the primary goal and are triggered at appropriate times as needed to represent the changes in the system. For this model, driving from point A to point B represents the primary mission. The competing goals that are represented are obstacles, appearance of a threat, redirection from headquarters, vehicle being stuck, and detection of a vehicle malfunction. In other words, the driver has been directed to leave his current position and drive to another specified location. It was assumed that planning has been completed and the driver knows where he is supposed to go.

While the driver is traversing the terrain to his new location, he may encounter obstacles and other difficulties. All the goals that appear will interrupt the primary mission.

3.1 Model Functions

The primary mission includes the functions necessary to drive from point A to point B. It includes four functions, "move," "see," "maintain situation awareness (SA)," and "communication". These functions all run concurrently in the model. Each of the functions is described separately (see figure 1).

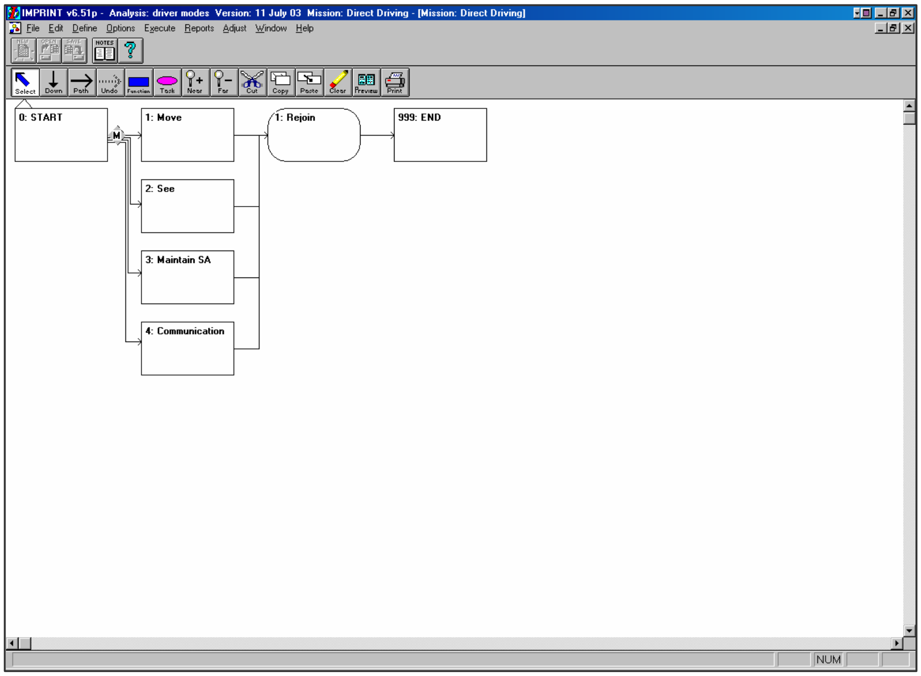

Figure 1. Primary mission task network.

The "move" function (figure 2) includes tasks that represent steering (and non-steering) and controlling the speed of the vehicle (acceleration, deceleration, and coasting). These tasks are set to occur in a cyclical fashion, meaning that once the vehicle has initially accelerated, a probabilistic decision is made whether the driver will accelerate, decelerate, or coast. Once this task is complete, the probabilistic decision is polled again with the choice to accelerate, decelerate, or maintain speed. Initial speed is set. The increase or decrease in the acceleration and deceleration tasks, respectively, can be set to the desired level. A minimum and maximum speed can also be set. The driver also cycles through the steer (adjust the steering mechanism) and do-not-steer (hold steady the steering mechanism) tasks.

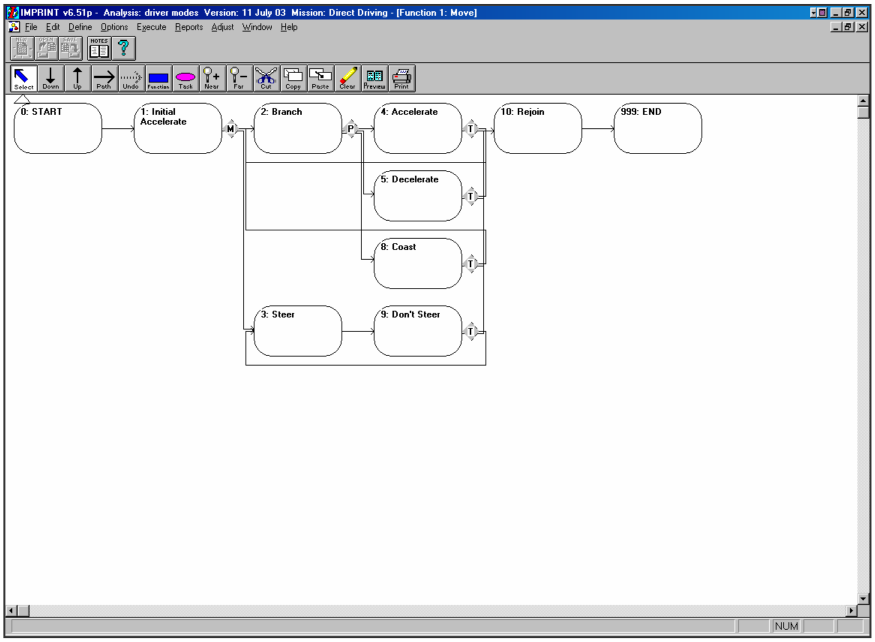

Figure 2. Move function task network.

Included in the "see" function are the tasks of scanning the sector, detecting landmarks, threats and obstacles, recognizing the path, calculating the distance to objective, and comparing to the guidance (see figure 3). First, the driver scans the sector. Then, the model will probabilistically determine if he sees an obstacle, threat, or landmark. If an obstacle (any physical object to be avoided) or threat is detected, the goal function "avoid hindrance" is triggered and the primary mission is interrupted. If a landmark is detected, the driver continues his tasks. The tasks of recognizing the path, calculating the distance to the objective, and comparing to guidance received are performed simultaneously. These three tasks represent higher cognitive processes while "scanning the sector" represents the perceptual process. That is why scanning the sector is executed before the three cognitive tasks. These tasks repeat to form a feedback loop similar to that described in Wickens' human information processing model (Wickens and Hollands, 2000).

Another function that repeats is the "maintain situation awareness" function (see figure 4). This function was added to the model as a direct result of the cognitive task analysis performed for this study. This function consists of cognitive processes that include assessing the orientation of the vehicle, assessing the motion of the vehicle, assessing the traction of the vehicle, and awareness of vehicle function. These tasks represent the flow of Wickens' model that does not require a lot of attentional resources and memory capacity. Particularly in a direct driving condition, they are highly learned and are performed almost automatically, based on cues from the environment. In teleoperated vehicles, the operator is required to devote much more attentional resources to assess these conditions. At the conclusion of the assessments, the model probabilistically determines if the vehicle has stopped moving or is malfunctioning. If either of

these conditions is true, the “remediation necessary” goal is triggered and the primary mission is interrupted.

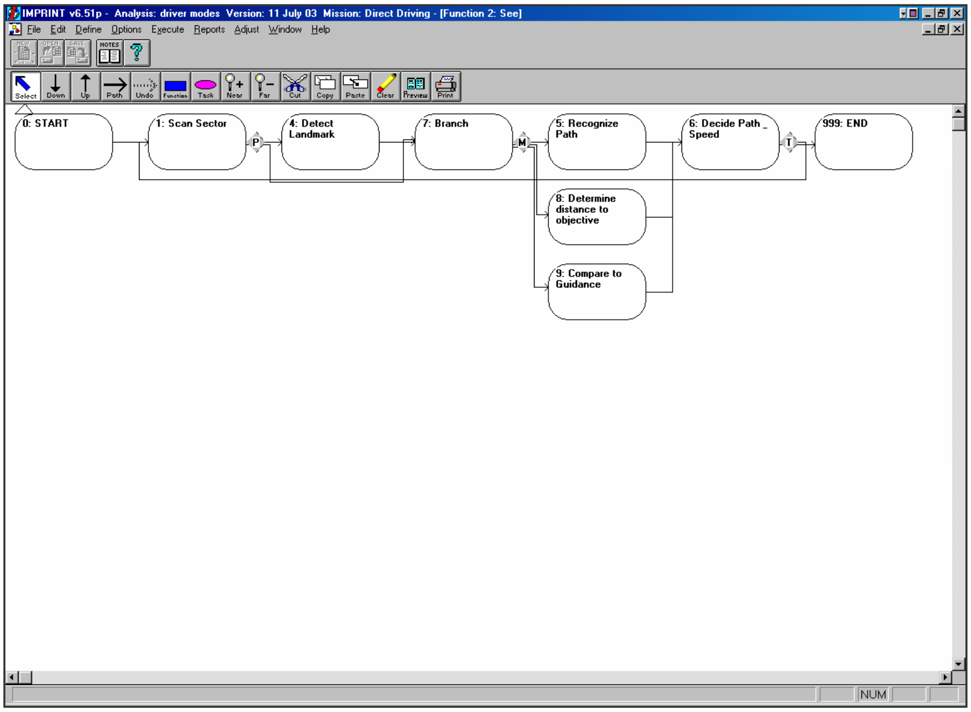

Figure 3. See function task network.

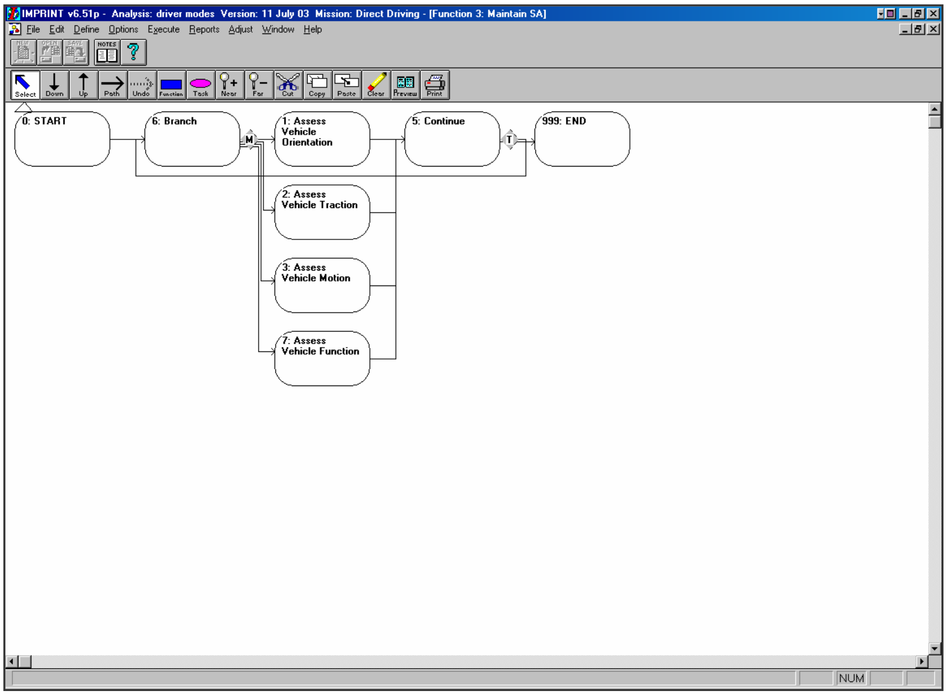

Figure 4. Maintain situation awareness task network.

The last function included in the primary mission is a "general communication" function (see figure 5). This function represents the operator communicating with other people outside his vehicle. The communications are modeled to be about 25 ±10 words; they are triggered randomly. At the end of each communication, the model will probabilistically determine if the communication leads to a redirection of the vehicle. If this condition is true, the "avoid hindrance" goal is triggered and the primary mission is interrupted. The tasks for redirection are similar to those for avoiding an obstacle.

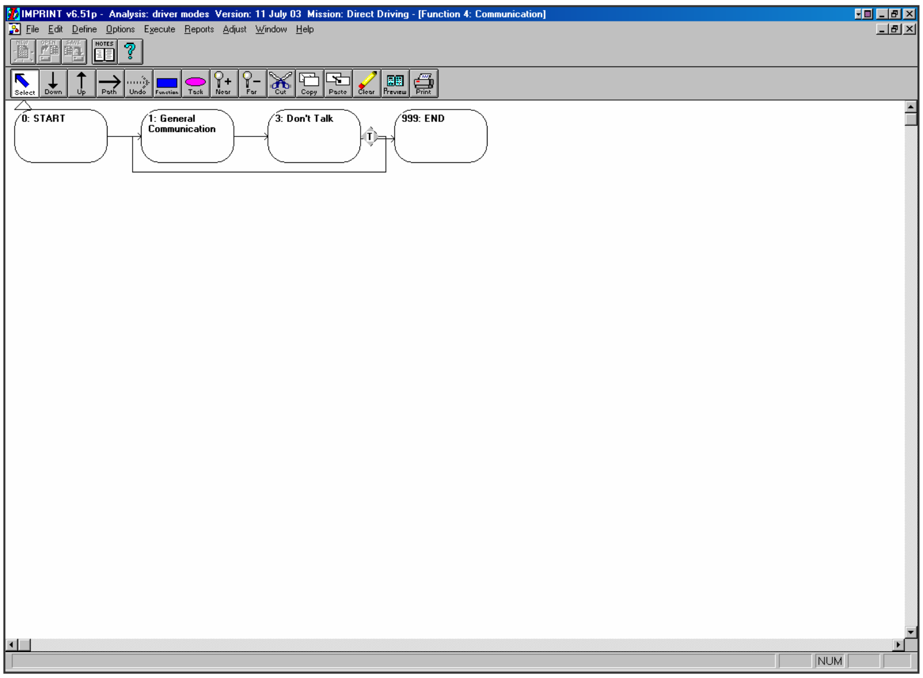

Figure 5. General communication task network.

There are two goal functions in this model. (As mentioned previously, they are "remediation necessary" and "avoid hindrance.") Remediation necessary is the higher priority of the two goals. However, because both goals are triggered in the primary mission and in both cases the primary mission is interrupted, these two goals cannot occur simultaneously.

The "avoid hindrance" goal represents tasks associated with avoiding obstacles, threats, and tasks associated with changing path based on a redirection (see figure 6). If a threat is detected, the immediate tasks triggered are accelerate, "hard" steer, and plan escape route. Then the operator will check to see if the threat is still present. There is a 25% chance that the threat will not be clear. If so, the operator recycles through the accelerate, hard steer, and plan escape route tasks. If the threat is clear, the operator will execute the task, scan sector, and drive. This is the first task executed if an obstacle or a redirection triggers the goal. The path for all three goal triggers is the same from this point on. Once the sector has been scanned, the operator will recognize the paths, determine distance to objective, and compare to guidance received. Then the operator chooses a new path and speed. At this time, the goal ends and the primary mission resumes.

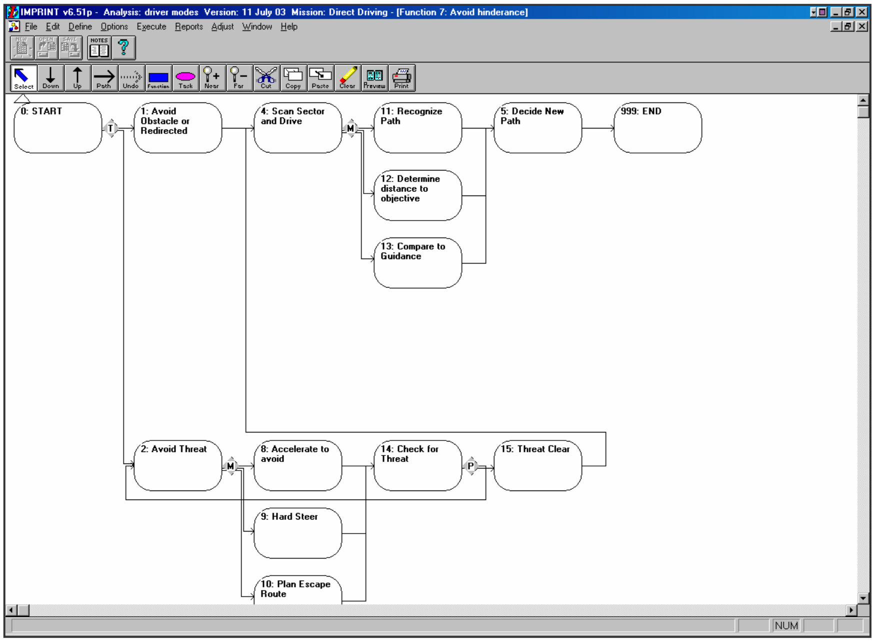

Figure 6. Avoid hindrance task network.

The "remediation necessary" goal represents tasks that will be executed when the vehicle is not moving or not operating correctly (see figure 7). If the operator determines that the vehicle is not operating correctly, he will stop (brake) the vehicle. He will then assess the systems that he can without getting outside the vehicle. He will decide if the problem can be fixed. There is a 5% chance that the mission will be aborted at this point. There is a 35% chance that the vehicle is damaged and the mission can continue with damage. If this condition is true, the vehicle will be limited to 6 miles per hour maximum speed. There is also a 60% chance that the operator can make some control adjustments to fix the vehicle. After the control adjustments, the operator will drive the vehicle and determine if the problem is fixed. There is a 65% chance that the problem is fixed and a 35% chance the operator will go back to the "brake" task and start over. If the problem is fixed, the operator will scan the sector and drive. If "remediation necessary" is triggered because the vehicle is not moving, the operator will assess for damage first. There is a 30% chance that damage has occurred and a 70% chance that there is no damage. If the vehicle is damaged, the operator will assess the damage to determine if it is reparable. At this point, there is a 5% chance that the mission will be aborted. There is a 35% chance that the operator will continue with the damage (a reduced maximum speed would then be set), and a 60% chance that the operator can make adjustments to repair the damaged system. After repair or if there is no damage, the operator will assess the vehicle's orientation. If the vehicle is not upright, the mission is aborted. The probability of this is 5%. The operator will then assess vehicle entanglement and traction. The model represents a 5% probability that the operator cannot untangle the vehicle and the mission will be aborted. For the other 95%, the operator then makes adjustments, drives the vehicle, and assesses the situation. If the vehicle moves, the operator continues with scanning the sector and driving. If the vehicle is still stuck, the operator returns

to the assess orientation task and starts over. There is a 65% chance that the vehicle is unstuck. As in the primary mission function "see" and the goal "avoid hindrance," after scanning the sector, the operator will recognize the path, determine the distance to the objective, and compare to his guidance. He will then select a new path and speed, and the goal ends. At this point, the primary mission resumes.

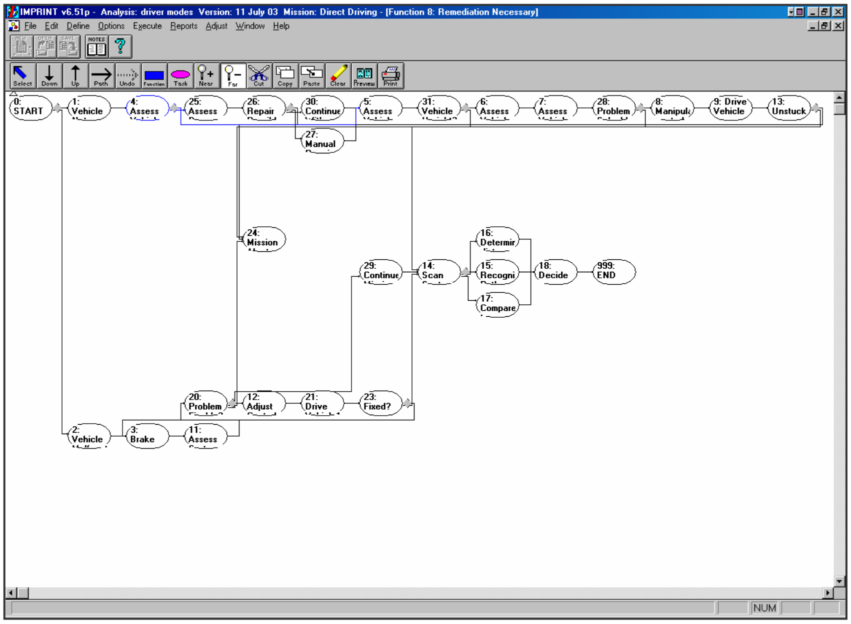

Figure 7. Remediation necessary task network.

3.2 Model Assumptions

When a task network model is developed, it is very difficult to represent reality. Many assumptions must be made so that the process modeled can examine the area of interest without every detail of the process having to be modeled. This is true of the models developed for this study. The assumptions may have to do with the way the process is represented or with specific aspects of the process. The easiest method for describing the assumptions is to address them as they apply to the level of autonomy that was used as one of the independent variables in the original investigation of driving control mode.

An off-road path was chosen for the scenario. It is assumed that the operator has already planned where he is supposed to go and that he is just starting. The vehicle, whether it was an actual vehicle driven by the operator or a robot, needs to traverse from the current position to some known position, 0.5 mile away. This distance can be adjusted. There may be threats and obstacles in the path. The operator may receive a communication that directs him to change course or the vehicle may become stuck or malfunction.

When the vehicle is driven directly, it is assumed that the operator stays in the vehicle. All operations, even repairing malfunctions or damage, can only be performed in the vehicle. This assumption was made so that the tasks for all three levels of autonomy are consistent.

Several assumptions were made about the control mechanisms for the teleoperated and semi-autonomous driving conditions. The workstation design that was modeled includes a video display and a joystick type controller. The display is a 120-degree field of view display with an operator-controlled switch that would shift the camera from left to right or vice versa. The joystick is assumed to be similar to those on many video games. The operator controls the direction and speed of the vehicle by moving the joystick forward to the left or right. He decelerates by pulling the joystick back. It is known that in both teleoperated and semi-autonomous modes, the vehicle speed is less than in direct driving (Scribner and Gombash, 1998). To represent this in the model, the probability that the operator will coast, decelerate, or accelerate can be adjusted appropriately in the "move" function.

The level of obstacles, threats, malfunctions, redirections, and mishaps is represented by probabilities in the model. In the "see" function, using mean time calculations, it takes about 6 seconds to complete all the tasks in the function. Using this time, one can then calculate the probability that an obstacle or threat would be encountered on each cycle through this function. The "communicate" function takes about 45 seconds. Again, this time can be used to set probabilities that the driver will be redirected. The "maintain situation awareness" function averages about 3 seconds. This time is used to adjust the probabilities that malfunctions would occur or that the vehicle would become stuck.

The percentages that were chosen in most cases represented the scenario chosen for the model. They were calculated so that the model would produce the conditions for the tests undergoing consideration. These values can be adjusted to represent different environments or test conditions.

4. Driving Validation

Validation of the driving model with a field study was considered initially. The output of the model indicated that driving was a high workload contributor and other distractions (primarily visual and cognitive) would result in the potential for performance errors. Output validation of this model by direct comparison of model output to field data is costly. This is primarily because of the difficulty in measuring mental workload and the danger in exposing subjects to levels of mental workload that would lead to possibly dangerous performance errors. Mental workload is the primary measure in this model. Mental workload can be measured by many different means, primary task measures, secondary task measures, subjective measures of workload, and such

(Sanders and McCormick, 1993). The difficulty would be in correlating those measures of mental workload with the measures in IMPRINT. That idea was abandoned because the literature shows that mental processing limits are approached when one is driving a vehicle. Many studies have been completed which show that additional distracters from driving would result in performance errors. The errors can range from lane maintenance to vehicle accidents.

This led to the establishment of validity by two methods. The first method of the validation is structural validation of the model constructs through comparison with other driving models. The second method, output validation, shows results from other studies that indicate driving is a high workload task.

4.1 Structural Validation

The first step in validating this model was to identify individuals or organizations that hold an expertise in driving and human behavior. Dr. John Lee of the University of Iowa has done extensive research in driving behaviors. The Virginia Tech Transportation Research Facility has also been involved in many years of human driving research. From these two sources and others identified through literature search, we were able to identify other research primarily in the area of modeling human driving behavior.

The initial validation of this driving model is face validity, which validates what is in the model. Face validity was accomplished by a comparison of model constructs with other widely accepted driving models. Levison described a "Driver Performance Model" that was developed in 1993 and has since been used as a basis for other driving models. The parts represented in Levison's model include perception, cognition, control actions, and decision making. This model is actually two models combined, a driver-vehicle model and a procedural model. The driver-vehicle model is a continuous feedback model between the driver's actions and the vehicle reactions. The procedural model looks at the driving tasks and determines task selection as it simulates the in-vehicle auxiliary tasks. The procedural model represents the regulation of attention. These components are all represented in our driving model.

Biral and Da Lio (2001) suggest that good driver models are required to predict vehicle performance. Their investigation revealed three main types of driver models. First, some models are based on conventional continuous control such as proportional integral derivative (PID) and generalized predictive control (GPC). The second type of driver models that exist are fuzzy logic or neural network-based controllers. Fuzzy logic controllers are popular for representing human behavior and neural nets for their capability to learn. Biral and Da Lio called the final class of driver model, hybrid and hierarchical models. These employ the other two previously described types. Of the driver models they identified, they determined that for models to represent realistic driving behaviors, they must functionally consider the following components: perception, cognition, decision, and motor process of the human.

Salvucci, Boer, and Lui (2001) use a cognitive architecture to model driver behavior. They characterized their model in terms of three primary components: control, monitoring, and decision making. The control component accounts for perception of control variables and motor control. The monitoring component accounts for monitoring the environment. The decision component is the cognitive process of determining if a lane change is necessary or safe.

Brown, Lee, and McGehee (2000) described a driver model of a rear-end collision warning. The results are a time history of the driver's response in avoiding a rear-end collision. It contains three major components. The first is a representation of the attention to the roadway based on the uncertainty of the driver. The second component describes the decision process for braking or travel. The third component describes the driver's response. Again, these are the perceptual, cognitive (including decision making), and motor processes.

Additionally, there has been some discussion about the adequacy of representing a continuous process (driving) with a discrete event simulation (ARL Technical Advisory Board, 2002). It can be argued that a continuous process can be represented in a discrete event simulation. Perhaps it is a series of discrete tasks that happen continuously with continuous input. The most continuous portion of driving would be the visual and cognitive processes. Even these can be described as discrete tasks. First, you glance ahead, then to the front left, then the front right, then the rear view mirror. At each glance, there would be perception and a decision about hazards, etc. If these tasks happen continuously, i.e., without a time interruption in the simulation clock, would that not represent a "continuous" process?

The point here is that all the human information processes represented in each of these other models are also represented in our discrete event simulation model. No human information processing pieces have been excluded. The representations may be different, but that is expected because the purpose for each of the driver models is different. Most driver models are built in a closed loop system with the vehicle so that the actions taken by the driver model will impact the vehicle performance, and that will, in turn, impact the next action of the driver. Our model was built to determine the attentional demands that are controlled in Levison's procedural model. The feedback loops with the vehicle are not represented in this model. The model is a stochastic model used to look at the different combinations of driving tasks that may happen concurrently. This provides the ability to identify how the driver's mental demand varies and to identify areas for potential performance degradation.

This model shows that the potential for performance errors during driving is great. There are many times in a model run when the driver's mental workload is near or above what might be considered a mental workload threshold, based on work by Reid and Colle (1988). This would indicate that any distraction from driving would increase the probability of performance errors. The next step in validating the model was to determine if the last statement is true through literature review.

4.2 Output Validation

The opportunity for distraction during driving is continually increased in today's society. The technology that is currently in use or being developed such as cell phones, in-vehicle navigation systems, car stereos with compact disc and cassette players, and mobile business services can all cause distraction from the primary task, driving. In addition to the "high tech" distractions, today's life styles offer other "low tech" distractions such as eating while moving, reading while commuting, applying make-up, or just concentrating on other aspects of our busy lives. Many of these distractions require similar mental loading to those tasks that would be required in military vehicles.

Many different organizations are interested in studies of how these types of distraction impact the human's ability to drive. Driver distraction and subsequent performance errors impact the safety of the vehicle. Therefore, insurance companies, automobile manufacturers, Government agencies, and other policy makers are all interested in this topic. As a result, many studies have been conducted to quantify and qualify the performance errors that may be caused by different driver distraction. Studies have been conducted in instrumented vehicles and in simulators. Almost all investigations show that any distraction from driving allows the potential for performance errors.

Cell phone use is one of the most common distractions from driving that has been studied recently. In 1997, Redelmeier and Tibshirani reported in the New England Journal of Medicine that cell phone use quadrupled the risk of collision during the period of the call. Strayer, Drews, and Johnston (2003) did a series of experiments that showed that talking on a hands-free cell phone during driving causes what they label "inattentive blindness". The experiments ranged from looking at driving performance errors to determining that drivers do not recall billboards that they fixated on while driving and talking on the cell phone. Direct Line Insurance (2000) has shown that reaction times for drivers averaged 30% slower when the driver was engaged in a cell phone conversation while driving than when the driver was legally over the limit for alcohol consumption and driving. Furthermore, the reaction times for drivers talking on a mobile phone were 50% slower than when they were driving without one.

Driving and distraction is a large research area. Tijerina (2000) reports that predicting costs and benefits of the driver distraction associated with in-vehicle technology is very complex and difficult. However, driver behaviors and operational problems with the technology can be evaluated. There is no doubt that crash data and driver distraction are related. There are, however, so many variables that it is difficult to predict what level of distraction would cause an accident. Tijerina uses the analogy to smoking and lung cancer. You will not necessarily get cancer from smoking, but the risk is much greater. Similarly, you may not have a performance error if you are distracted while driving, but the risk of error is much higher.

5. Discussion and Future Work

Validation of a model is an important process. A validation approach depends on the purpose of the model. It is completed “from the perspective of the intended use” (Department of the Army, 1997). In this case, validation implies that the representation of driving is correct for determining the mental workload associated with driving tasks in a military combat vehicle. When one is comparing the model constructs with other driving models, this model includes all the components of human information processing included in the other models. There do not appear to be incongruencies. Additionally, all the studies investigated showed that mental workload was at or near the threshold during driving. This is consistent with the results of this driving model in both studies. This implies that additional mental workload would result in an increase in the potential for performance errors. Based on these comparisons, it is believed that this representation of driving is valid for the purpose that it is used, most recently vehicle crew workload analysis.

Additional work is planned to further validate the driving model and further validate the finding that in a combat vehicle, the driver should not be required to perform additional tasks unless driving is fully and reliably automated. Two separate studies are planned. The first study is to use the driving tasks from this model to represent teleoperation. The driving tasks will not change but the workload will be different because of the modality and attentional demand of the task. The revised model will then be used in a “model-test-model” approach to predict operator performance during the teleoperation of an unmanned ground vehicle while the operator travels in a moving vehicle (Hill, Tauson, and Stochowiak, 2003). Model predictions of performance and test results will be compared and the model will be adjusted to better represent the actual teleoperation. The model output will then be validated with test results from ensuing study.

The second study being considered is a validation of the workload threshold predicted by the model. This study will use an actual vehicle on an outdoor course. The driver will be required to operate the vehicle separately while completing secondary tasks. Secondary tasks will mimic typical tasks that are performed during driving, both in the civilian world and the military, talking on the radio, talking to other individuals, looking for hazard indicators, etc. The expectation is that each of these distractions will cause a decrease in performance. This study approach is still being defined and has not been formally proposed.

This model appears to be an acceptable representation of driving for the purpose that it is being used. The results of the two studies should further validate the model.

This work is valuable to the Army in the design of any vehicle but primarily, combat vehicles. Even if driving were automated, the visual and cognitive workload associated with monitoring or intervening in an autonomous mode would require that the operator be focused on driving alone

during some intervals. Although technological advances are promising, current technology requires the full attentional demand of the driver. This driving model is therefore an important component in the determination of the functional allocation between crew members in military vehicles.

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